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GUIDE TO BARE BASE POWER PLANT INSTALLATION

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Operations

GUIDE TO BARE BASE POWER PLANT INSTALLATION

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This handbook is designed to assist you in establishing a power plant network at a bare base or remote location. It discusses in a generic sense bare base power requirements, site selection and layout, primary electrical connections, safety considerations, and basic maintenance and emergency planning requirements. When coupled with information contained in AFPAM 10-219, Vol 5, Bare Base Conceptual Planning Guide, and instruction received at Silver Flag training sites, electrical and power production personnel should be capable of effectively setting up a bare base primary power generation system.

Figures

Tables

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INTRODUCTION

GUIDE TO BARE BASE POWER PLANT INSTALLATION

PURPOSE OF HANDBOOK

This handbook addresses the actions necessary to establish a primary power generation system at a bare base location using existing Harvest Falcon electrical assets (figure 1). It is meant to be used by civil engineering power production and electrical personnel responsible for installation, operations and maintenance of the bare base electrical system. Users of this booklet are assumed to have a basic knowledge of bare base assets and their use—readers without this fundamental knowledge should review AFPAM 10-219, Volume 5, Bare Base Conceptual Planning Guide; AFH 10-222, Volume 1, Guide To Bare Base Development; and AFH 10-222, Volume 2, Guide To Bare Base Assets.

Figure 1. Harvest Falcon Electrical Assets.

REQUIREMENTS AND OPERATIONAL FEATURES

Planning Factors

In the Harvest Falcon system much of the electrical planning is "preordained" by the quantities of electrical assets contained in the various deployment sets. Assuming the engineer and logistics planners on the Unified and Component Command staffs have properly identified Harvest Falcon needs, sufficient assets should flow into a beddown location. Deployed engineer personnel essentially set up the electrical equipment items when they are received and do not normally have to be concerned with whether generation capacity will satisfy base demands.

Most bare base deployments will use a squadron of aircraft and its associated population as the basic building block. Harvest Falcon assets are configured to support this basic building block using three types of prepackaged sets—housekeeping, industrial, and initial flightline support. If additional aircraft squadrons are deployed to the same location; a fourth set, a follow-on flightline set, is provided for each added squadron. Any associated population increases are covered by additional housekeeping sets. Table 1 depicts the mix of Harvest Falcon packages supporting up to 3,300 personnel and three squadrons of aircraft.

Table 1. Harvest Falcon Deployment Packages.

HARVEST FALCON BEDDOWN EXAMPLE		
One Squadron 1,100 Personnel	Two Squadrons 2,200 Personnel	Three Squadrons 3,300 Personnel
Housekeeping Set	Housekeeping Set *Housekeeping Set*	Housekeeping Set Housekeeping Set *Housekeeping Set*
Industrial Ops Set *Initial Flightline Sup Set*	Industrial Ops Set Initial Flightline Sup Set *Follow-On Flightline Sup Set*	Industrial Ops Set Initial Flightline Sup Set Follow-On Flightline Sup Set *Follow-On Flightline Sup Set*

Within these deployment packages are contained various quantities of the electrical system assets necessary to establish the base's electrical power generation and distribution network. Types and quantities of major components used in the power plant set up are shown in table 2. Note that these items are included in the housekeeping and industrial operations packages. There are also electrical assets (primarily secondary distribution centers (SDC)) contained in the flightline sets but these generally pertain to the distribution system rather than power generation. While the housekeeping and industrial operations sets should normally be among the first packages to arrive at a bare base, be aware that there are many aircraft sorties required to move these two packages in and electrical components account for only a fraction of the total items moved. You will likely not see all electrical components arrive at the same time. The quantities of cable skids and remote area light sets shown in table 2 are meant to serve the entire generation and distribution system, not just the power plant(s).

Table 2. Harvest Falcon Power Generation and Distribution Assets.

Asset Type	**Prepackaged Set**	
	Housekeeping	Industrial Operations
750-kW Generator	4	1
Primary Distribution Center	2	
Cable Skids	6	
Fuel Bladders	2	1
Expandable Shelter Container	1	
Remote Area Light Set	6	
Equipment Rack	1	

The basic planning factors used in developing the Harvest Falcon electrical package were 1.5 kW per person for the housekeeping set raising to 2.7 kW per person when the industrial and flightline packages were added. If you are faced with expanding the electrical system on your installation, these same planning factors can be used as a starting point. Once you have calculated the potential added load, you can request additional Harvest Falcon assets to be shipped in. Most Falcon electrical components can be requested singularly. For example, unit type code (UTC) XFBE7 contains one 750 kW generator and XFBEF contains one primary distribution center. See AFH 10-222, Volume 2, Annex F for additional UTCs.

Basic Concepts

Before you begin work it is important to brush up on some basic fundamentals. The current required by induction motors, transformers and any other device consists of two separate components: *magnetizing current* and *power-producing current*. This concept of two types of current is particularly helpful in understanding what power factor is and the problems associated with low power factors. Power-producing current is converted by the equipment into work. This working power is measured in kilowatts (kW). Magnetizing current is required by the equipment to produce the magnetic flux necessary for operation of all inductive devices. This is referred to as reactive power and is measured in kilovolt-amperes-reactive (KVAR). Total current is what would be read on an ammeter, and has both a reactive and working component. The unit of measurement of this apparent power is the kilovolt-ampere (KVA).

Power Factor

You should also be aware of what power factor is as well as the influence it has on your power generating system. Power factor is the relationship between working (active) power and total power consumed (apparent power). Essentially, power factor is a measurement of how effectively electrical power is being used. The higher the power factor, the more effectively electrical power is being used and vice versa.

The Harvest Falcon distribution system's operating power is composed of two parts: Active (working) power and reactive (non-working magnetizing) power. The **ACTIVE** power performs the useful work….the **REACTIVE** power does not. Its only function is to develop magnetic fields required by inductive devices.

A great deal of equipment utilized in the Harvest Falcon set as well as unit and personal equipment people bring with them during a deployment cause poor generating plant power factor. One of the worst offenders is the lightly loaded induction motor. Generally, the power factor at the power plant decreases with increased motor (reactive power) loads. Therefore when more inductive reactive power is produced, more apparent power is also needed to compensate. Because of the inductive reactance placed in the system by air conditioner compressor and fan motors, fluorescent light ballasts, and lightly loaded SDC transformers; the system power factor often ranges between 0.70 and 0.90. At some locations during the Gulf War, the power factor of the Harvest Falcon electrical system dropped as low as 0.45 and averaged only 0.68. The effect of the power factor on your generation capability could be substantial. The lower the power factor the more generation capacity is needed to support a given load. For example, if your power factor is 0.70 to support a load of 100 kW (real power), you will need to generate 143 KVA (apparent power). Unless you have the ability to add capacitor banks (not part of Harvest Falcon equipage) to your system or capacitors to your inductive devices, this power factor effect must be considered when planning and establishing power plants. Use a power factor of 0.80 as a starting point for planning activities.

Removing system KVAR improves the power factor. Improving the power factor releases system capacity and permits additional loads to be added without overloading the system. As power factor increases, KVAR decreases better utilizing the electrical power you're producing. For example, in a typical system with a 0.80 power factor, 800 kW of real power is available for the load while 1,000 KVA of apparent power is being generated. By correcting the system to unity (1.0 power factor), the kW will equal the KVA. Now your system will support 1,000 kW, versus the 800 kW at the 0.80 power factor; an increase of 200 kW of productive power.

Layout of Distribution System

Now it is time to go to work. Draw a rough layout of your Harvest Falcon electrical distribution system showing the location of generators, primary distribution centers (PDCs), and SDCs. In laying out the system, your chief concern will be supplying electric energy at voltages necessary to operate the consuming equipment. Electric power from host nation sources is used if available, unless inadequate or subject to frequent interruption. On deployments where it is not possible to connect to host nation commercial sources, bare base generators are used.

Load Estimation

The entire layout of the distribution depends on load estimation. Load estimation covers both location of the load and magnitude of the load.

Location of the Load. To estimate the load, first obtain a rough drawing or layout of the designated area for beddown of the force. Now locate on it where you plan to set up your generating plant(s) and mark the various facilities to be connected to the distribution system. Identify each shelter, such as billeting tents, command posts, warehouses, and shops.

Determining Magnitude of Load. If time permits, you should take the extra effort to be more precise in determining your electrical requirements by applying demand and diversity factors. Application of these factors provides a closer estimate of actual potential load on a power plant. From a bare base perspective this could prevent shipping in redundant equipment and free airlift sorties for other important bare base support items.

The starting point for your load determination should be calculating the connected load on the system. The connected load is the sum of the rated capacities of all electrical appliances, lamps, motors, etc., connected to all the circuits of the system. Many times this data can be found on name plates of motors, air conditioners, and electrical equipment. If time does not permit or you do not have access to the data, you can use table 3 as a guide for determining connected loads.

Table 3. Connected Load Table.

Type of Facility Basic Function	Connected Power (KVA)	Connected Air Conditioners (KVA)
Temper/Admin/Command	5.7	10
Temper/Billets	4.5	10
ESC/Power Plant	5.8	10
GP/Warehousing	6.9	20
Temper/ 9-1Kitchen	100	40
Temper/Shower-Shave	6.0	
Temper/Latrine	6.0	
Temper/Laundry	10	10
ESC/Avionics Shop	15	10
GP/Avionics Shop	15	20
Temper/Engr Util Shop	5.8	10
Temper/Engr Struct Shop	11.6	10
Temper/Engr HVAC Shop	7.8	10
Temper/Engr Elect Shop	7.3	10
Temper/Engr Fuels Shop	7.2	10
GP/Engr Power Pro Shop	9.7	20
GP/Engr Equip Shop	6.9	20
ESC/Pneudraulics Shop	28.1	10
ESC/NDI Shop	7.7	10
FSTFS/Propulsion Shop	36	
GP/Propulsion Shop	15	20
ESC/Elect Shop	15.6	10
ESC/Bearings Shop	5.8	10
GP/AGE Shop	8.2	20
ESC/Parachute Shop	6.6	10
ACH/Hanger	36	
ESC/Wheel/Tire Shop	6.0	10

Type of Facility Basic Function	Connected Power (KVA)	Connected Air Conditioners (KVA)
GP/Gen Maint Shop	10	20
ESC/Gen Maint Shop	8.0	10
Temper/Sqd Ops	5.9	10
ESC/Life Support Shop	5.7	10
GP/Sqd Ops Support Shop	6.5	20
Temper/Base Admin	5.6	10
Temper/Post Office	3.9	10
Temper/Legal Office	4.9	10
Temper/BX	6.0	10
ESC/BX	8.0	10
GP/Gen Support	7.0	20
Temper/MWRS	4.6	10
ESC/Comm Facility	9.0	10
ESC/Armory	4.5	10
ESC/SRC	4.5	10
Temper/Fire Ops	4.5	10
Temper/Fire Tech Svs	5.0	10
Temper/Security Force	4.5	10
Temper/EOD	6.2	10
Temper/Base Ops	4.5	10
Temper/Engr Readiness	4.5	10
Temper/Mortuary	6.3	10
Temper/Aerial Port	4.5	10
GP/Aerial Port	6.5	20
GP/Munitions Maint	8.2	20
ESC/POL Lab	4.5	10
Temper/Alert Facility	5.4	10
ESC/Supply Processing	5.1	10
FSTFS/Supply Storage	10	
Temper/Vehicle Ops	4.5	10
Temper/TMO	4.5	10

Type of Facility Basic Function	Connected Power (KVA)	Connected Air Conditioners (KVA)
FSTFS/Vehicle Maint	18.5	
FSTFS/Packing/Crating	12.0	
Temper/Briefing	7.0	10
Temper/Ops/Plans	4.6	10
Temper/Intel	5.6	10
Temper/Maint/Job Cont	4.8	10
Temper/Maint Mat Cont	6.3	10
Temper/Maint QC	6.3	10
ESC/Intel	5.6	10

A connected load must be converted to a demand load. Demand is the maximum KVA required to serve a given connected load. Demand is less than connected load because all connected equipment seldom is operating simultaneously. The ratio between demand and connected load is the demand factor. Therefore, the demand factor is usually less than 1.0. Your more senior power production personnel should be able to provide realistic estimation of the demand factor for various facilities based on the mission of the facilities and what electrical equipment is installed. Table 4 can also be used as a guide for determining demand loads. Compute the demand for each facility and record it on your layout drawing at the proper location (multiply connected load estimate by demand factor). This data could prove invaluable if demand loads increase beyond the capacity of the number of generators provided in your Harvest Falcon set and you must request additional support. Once beddown operations are complete, it is advisable to take actual demand readings at each facility. These more accurate data should be recorded so that they will be available in the case of a future base expansion.

Diversity Factor

Once demand loads on all facilities and supporting equipment items are identified, the maximum demand of all facilities as a whole is determined. The maximum demand of all facilities as a group is less than the sum of the individual facility demands. This is true because at no time would the lights, appliances or motors in all the facilities be used at exactly the same time. The maximum demand of all facilities as a group is calculated by applying a diversity factor against the demand load of individual facilities and totaling the resultant figures. Like the demand factor, the diversity factor is based on experience and is usually less than 1.0. The Harvest Falcon electrical system was built using a diversity factor of 0.7. An indication of a diversity factor to use at your location could be obtained from power plant logs. The ratio obtained when comparing average daily peak KVA against the total of the individual facility demands should provide an initial estimate. Use common sense when applying the diversity factor, however. It should not be applied to those equipment items that would likely operate in unison, for example, air conditioning units. In developing the Harvest Falcon system, the demand load for air conditioners was left at 100% rather than being reduced using the 0.7 diversity factor. Once you have applied the demand and diversity factors to the connected load at your installation, you should have a relatively realistic idea of the power plant requirement.

Voltage Drop and Regulation

Even though the Harvest Falcon electrical system is normally set up as a looped network, voltage drop will occur, primarily through line loss from impedance. Voltage drop in a system has a detrimental effect on equipment and resistance-type devices. Motors run with less efficiency and tend to overheat and lighting becomes dimmer or may not work at all in the case of fluorescents. To reduce the effects of voltage drop on lighting and equipment, primary runs should be kept to 4000 feet or less and secondary circuit runs limited to 800 feet or less if possible. The 4000 feet primary run assumes load concentrated at end of circuit. If load is evenly spaced along the run, the run can go up to approximately 1.5 miles. The transformer taps on secondary distribution centers (figure 2) also can be used to adjust for voltage drop. Several tap settings (two for high voltage, four for low voltage) exist on the primary side of an SDC permitting the secondary voltage to be maintained relatively steady. Changing the tap settings, however, is not a quick task. You will have to remove panels from the SDC and rewire the tap connections.

Table 4. Demand Factors.

Type Facility	Demand Factor
Temper/Admin/Command	0.9
Temper/Billets	1.0
ESC/Power Plant	1.0
GP/Warehousing	0.6
Temper/ 9-1Kitchen	0.9
Temper/Shower-Shave	0.9
Temper/Latrine	0.8
Temper/Laundry	0.9
ESC/Avionics Shop	0.7
GP/Avionics Shop	0.7
Temper/Engr Util Shop	0.6
Temper/Engr Struct Shop	0.6
Temper/Engr HVAC Shop	0.6
Temper/Engr Elect Shop	0.6
Temper/Engr Fuels Shop	0.6
GP/Engr Power Pro Shop	0.6
GP/Engr Equip Shop	0.6
ESC/Pneudraulics Shop	0.7
ESC/NDI Shop	0.7
FSTFS/Propulsion Shop	0.8
GP/Propulsion Shop	0.7
ESC/Elect Shop	0.7
ESC/Bearings Shop	0.7
GP/AGE Shop	0.7
ESC/Parachute Shop	0.8
ACH/Hanger	0.9
ESC/Wheel/Tire Shop	0.7
GP/Gen Maint Shop	0.8
ESC/Gen Maint Shop	0.7
Temper/Sqd Ops	0.9

Type Facility	Demand Factor
ESC/Life Support Shop	0.8
GP/Sqd Ops Support Shop	0.7
Temper/Base Admin	0.9
Temper/Post Office	0.9
Temper/Legal Office	0.9
Temper/BX	0.9
ESC/BX	0.8
GP/Gen Support	0.7
Temper/MWRS	0.8
ESC/Comm Facility	0.7
ESC/Armory	0.9
ESC/SRC	0.9
Temper/Fire Ops	0.7
Temper/Fire Tech Svs	0.8
Temper/Security Force	0.7
Temper/EOD	0.7
Temper/Base Ops	0.7
Temper/Engr Readiness	0.7
Temper/Mortuary	0.8
Temper/Aerial Port	0.8
GP/Aerial Port	0.8
GP/Munitions Maint	0.7
ESC/POL Lab	0.7
Temper/Alert Facility	0.9
ESC/Supply Processing	0.8
FSTFS/Supply Storage	0.9
Temper/Vehicle Ops	0.7
Temper/TMO	0.7
FSTFS/Vehicle Maint	0.7
FSTFS/Packing/Crating	0.7
Temper/Briefing	0.9
Temper/Ops/Plans	0.8

Type Facility	Demand Factor
Temper/Intel	0.8
Temper/Maint/Job Cont	0.8
Temper/Maint Mat Cont	0.7
Temper/Maint QC	0.8
ESC/Intel	0.8

Loading of Transformers

The secondary distribution centers at the load end of the Harvest Falcon distribution system feed 120/208 volt, three-phase power to facilities and equipment throughout the base. How these facilities and equipment items are loaded on the three phases has serious implications on the power generation system. All attempts should be made to balance the loads on each of the lines from the individual SDCs. For example, spread lighting loads across all three phases of the low voltage supply. Furthermore, you should attempt to evenly spread the loads across all SDCs fed from a single PDC. Having unbalanced loads placed on the SDC transformers and generators causes voltage variations between phases and could eventually damage primary generators.

Figure 2. Taps on a Secondary Distribution Center.

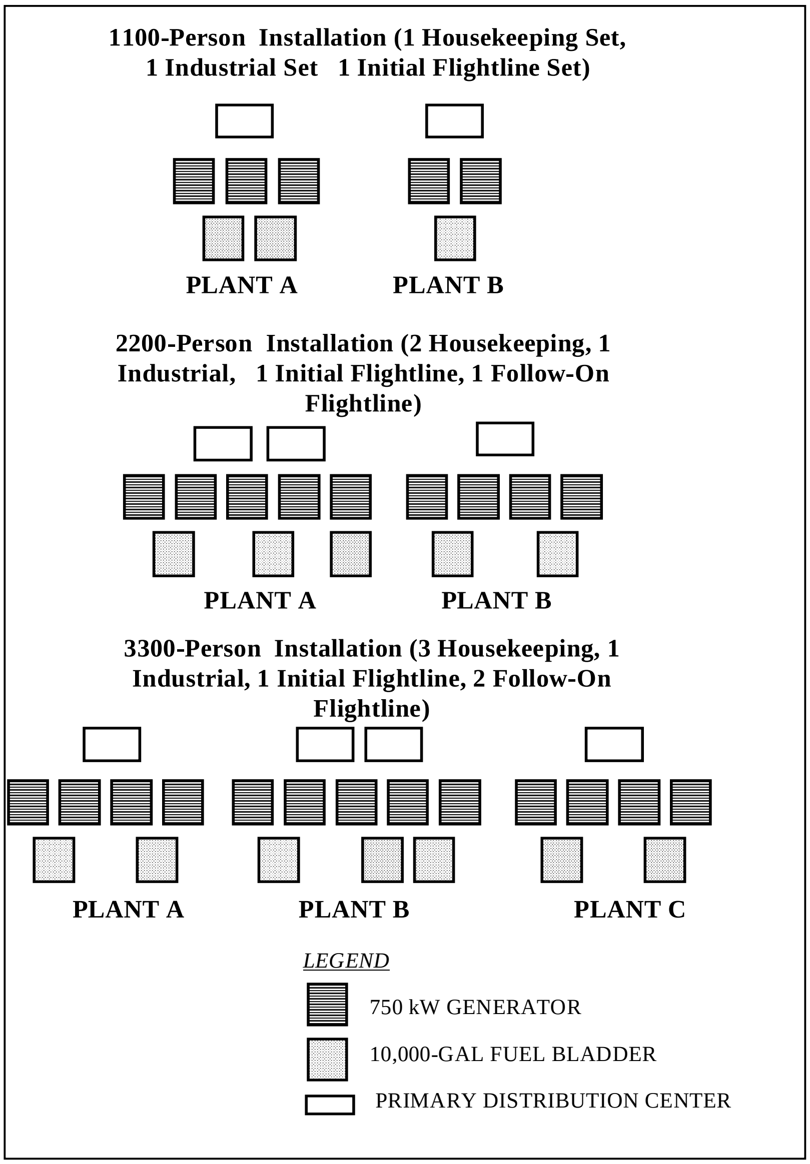
Threat Influence

A major consideration in establishing power generation capabilities at an austere location is the anticipated threat our forces might be facing. The degree of threat dictates the steps taken to protect power plant assets. As a rule of thumb, if you are facing a medium or high threat, disperse your power plants, i.e., have more than one plant on your installation. In this way the loss of one plant will not totally shut down electrical service to your installation or completely wipe out all your primary power generation assets. If the threat is low, one central plant should be satisfactory. Threat information can be obtained from your local Office of Special Investigation (OSI), Security Force, and Wing Intelligence personnel.

When choosing a power plant dispersal tactic, keep in mind you will have to man each plant in some fashion and you will not have unlimited equipment available. Basically you will have multiples of the equipment shown for the housekeeping set in table 2 (plus the one generator from the industrial package) depending upon the population at your base. There are several variants of power plant layouts that can be set up with the equipment assets. Figure 3 shows typical examples. At most bare base locations a closed looped electrical distribution system will be installed. Dispersed plants should be tied into the distribution system via connections through primary distribution centers. When tied into a ringed or closed looped distribution system, power plants can provide power in two directions increasing the operational survivability of the power network.

To further increase survivability of electrical generation and distribution assets, consideration should be given to hardening main generators, standby generators, PDCs and SDCs. Such hardening can be accomplished by reveting these assets using sandbags; earth berms; or B-1, sandgrid, or concertainer revetment materials. See AFPAM 10-219, Volume 2, Preattack and Predisaster Preparations, for details on construction of these types of facilities.

Figure 3. Typical Power Plant Layouts.



Responsibilities of 3E0X1 and 3E0X2 Personnel

Multiskilling of power production and electrical personnel is critical for installation and operation of bare base power generation and distribution systems. Neither specialty has sufficient numbers of people on our standard mobility teams to accomplish all beddown and recovery tasks following traditional skill breakouts. Contingency training programs direct several training activities meant to enable engineer personnel to perform beyond traditional peacetime-related skill requirements. In the context of power plant and electrical distribution system installation and operation, table 5 highlights the responsibilities of power production and electrical personnel:

Table 5. Task Responsibilities.

Task	Primary	Multiskilling
Set Up Power Plant	Power Production	Electrical
Operate Power Plant	Power Production	Electrical
Set Up Distribution System	Electrical	Power Production
Connect Tactical Generators	Power Production	Electrical
Install RALS	Electrical	Power Production
Phase/Parallel Generators	Power Production	Electrical
Install Grounding System	Electrical/Power Production	
Set Up Telescopic Light Set	Electrical/Power Production	
Construct Revetments	Electrical/Power Production	

TOOLS, EQUIPMENT AND SAFETY

Rubber Protective Equipment

When establishing a bare base power plant probably the most important item of rubber protective equipment you will need is a pair of rubber gloves. For use on the Harvest Falcon electrical system the gloves must be rated at not less than 7,500 volts. Leather protector gloves must always be worn over the rubber gloves to prevent physical damage to the rubber while work is being performed (figure 4). When rubber gloves are not in use, they should be stored in a canvas bag to protect them from mechanical damage or deterioration from ozone generated by sun rays. Rubber gloves should

Figure 4. Use of Rubber Gloves During Electrical System Maintenance.

always be given an air test by the using electrician each day before work is started or if the electrician encounters an object that may have damaged the rubber gloves. While rubber gloves are not part of the electrician's consolidated tool kit, two pairs (with leather protectors) are included in the Prime BEEF team kit. These are rated at 17 kV, more than adequate for support of the Harvest Falcon electrical system. Electrical team chiefs must ensure that the required periodic laboratory testing of these gloves is performed before deployment. During deployment it is important for the electricians to perform air tests and visual inspections of rubber gloves (figures 5 and 6). If there is any reason to suspect the electrical integrity of the rubber gloves, they must be removed from service immediately.

Figure 5. Air Testing of Rubber Gloves.

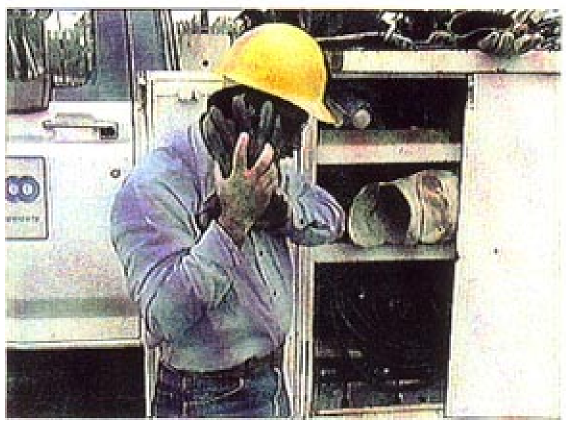


Figure 6. Visual Inspection of Rubber Gloves.

Hot Line Tools

For safety purposes common hot sticks must be used for making high voltage connections and performing maintenance actions on the system (figure 7). Most common actions include making cable connections to the main generators and the load and line sides of primary distribution centers. Removing and closing fuse switch assemblies are also tasks requiring a hot stick. Whereas a standard hot stick is used for the switching tasks, a more specialized stick is used for cable connecting. Typical of such a specialized tool is the Grip-All Clamp Stick (figure 8). This device features the capability to firmly grasp the load break elbows on the installation/removal pulling rings. The Prime BEEF team kit contains a Grip-All Clamp Stick and a fiberglass telescoping hot stick. It is critical to keep these two items in good condition since similar tools may not always be included in the Harvest Falcon electrical package. It is also advisable to include a grounding stick in the team kit since these are not available in the Harvest Falcon package.

Figure 7. Using Hot Sticks To Close Protective Switching Devices.

Proper care of hot line tools is also critical. It will not only result in longer life of the tool, but will result in greater safety and produce added confidence on the part of the craftsman using the tool. One of the most important factors in the care and use of hot line tools is to keep them dry. They should never be laid on the ground; they should be kept in a padded rack in a truck, tool trailer, or appropriate container until ready for use. If it is necessary to lay the tool on the ground; a clean, dry tarpaulin should be spread to prevent the tool from contacting the ground. Wood tools that have been subjected to moisture should be dried as soon as possible. Check each hot line tool before use for indications that the tool may have been damaged or overstressed; this type of damage is evidenced by bent or cracked parts. Never permit an obviously damaged tool to be used, and do not exceed the manufacturer's ratings in the use of hot line tools. The craftsman should always become accustomed to the use of a new tool before handling energized conductors or devices with it. Lastly, electrical team chiefs must ensure that the required periodic testing of hot line tools is performed before deployment. During deployment, hot line tools is performed before deployment. During deployment, hot line tools must be tested after repairs, refinishing, or waxing using a Chance LS-80 Hot Stick Tester.

Figure 8. Grip-All Clamp Stick.

Meters

One of the most critical tasks that must be accomplished during the installation of the Harvest Falcon electrical distribution system is testing of cable and equipment prior to system energizing. As a minimum, you will need a megohmmeter for conducting these checks. This meter is not included in the Harvest Falcon package, therefore you will have to bring one with you from home station. Test all primary cable runs for continuity prior to energizing to ensure cable insulation has not been damaged either through shipment or handling. PDCs also need to be checked to ensure internal components have not been damaged during shipment. You should test all three phase-to-phase and three phase-to-ground connections. You are looking for infinite readings; see TO 35CA1-2-6-1 for details.

High Voltage Safety

Although the Harvest Falcon electrical system is configured for field operation and differs greatly in appearance from permanently installed electrical systems, it is, nevertheless, a high voltage power generation and distribution network. The same safety principles and practices must prevail. The following are major safety guidelines to be considered:

Use only qualified electrical personnel on high voltage distribution system maintenance and repair work.

Use only qualified power production personnel on maintenance and repair of high voltage power generation equipment.

Ensure only electrical and power production personnel participate in the installation and set up of the Harvest Falcon electrical system components.

Review single line drawings of any in-place host nation electrical system or previously deployed Harvest Falcon electrical assets prior to commencing high voltage work (assumes tie in with existing systems).

Use crew size appropriate to the task and safety requirements (normally at least two personnel).

Conduct an on-site review of task requirements and safety precautions.

De-energize lines and components whenever possible before starting work.

Follow standard lockout/tagout procedures for isolating lines and systems.

Provide temporary grounding on systems being worked on.

Ensure all workers know and understand minimum working distances for high voltage work.

Keep unqualified personnel at least 10’ away from work on high voltage components.

Ensure all workers wear/use safety equipment and tools appropriate to the task.

Ensure work on live systems is performed under the direction of a full time supervisor.

Excavation Safety

During the initial stages of an operation using Harvest Falcon assets, the electrical distribution network is an above-ground system. If the contingency matures and an extended situation develops, above-ground electrical lines are normally buried. No manholes or long conduit runs are used; the lines are merely placed in trenches about 18-inches deep with a 6-inch separation between cables (figure 9). At locations where cables cross

Figure 9. Burying Of Electrical Cables.

roadways the lines are given a little more attention. They are buried even in the initial phases of the operation. If burial of the entire distribution system takes place, consideration should be given to running the lines in conduit under roadways and improving roads over these cables with gravel or hard surface. Within the power plant areas cables are also buried. Most trenching is accomplished using the trencher (figure 10) included in the Harvest Falcon set although some hand work will be required near generators, PDCs and SDCs. Electrical personnel must be prepared to operate this piece of equipment if they want uninterrupted progress in completing cable burial. The trencher is part of the bare base vehicle support package, not part of the electrical system. Keep alert for its arrival and familiarize yourself with its operation immediately. With any trenching operation, some preparatory work is necessary. If on an installation with existing electrical and communications systems, check host nation base utility prints for utility line locations and coordinate with the communications folks on locations of their cables. In the immediate power plant areas this should not be a major concern but remember that if multiple plants are used, lines will have to be run between them. These could be relatively long, traversing much of the camp area and contact with other utility systems is probable. When using the trencher, keep personnel at a safe distance from the tractor and cutting wheel and if an obstruction is encountered, shut down the machine before investigating the situation. Be especially safety conscious when trenching in the proximity of live electrical lines. Mark areas to be trenched clearly and use a spotter.

Figure 10. Harvest Falcon Trencher.

Switching and Tagging

Even though we are working in a deployed mode with the Harvest Falcon system, maintenance and repair activities must adhere to traditional safety practices to protect both our people and the equipment. If work has to be performed on the system once established, strict switching and tagging procedures must be followed. The procedures used in our daily peacetime home station operations work equally well with contingency equipage. Electrical supervisors must ensure that all personnel having occasion to work on the system know what they are doing and are supervised closely. When performing work on the high voltage portion of the system, the following procedures and guidelines must be followed:

Ensure all workers understand what is to be done, what hazards are prevalent, and what has to be been done to eliminate/mitigate the hazards.

Ensure all workers have functional and proper equipment and safety gear.

Develop step-by-step instructions and annotate them on a facilities safe clearance form (AF Form 269) (ensure copies of AF Form 269 and the warning tag forms listed below are included in the Prime BEEF team kit).

Shut down the system by isolation of all energy sources.

Secure all applicable switches/controls by removing fuses/opening cut outs/etc. Typical actions would be to remove arc strangler switches from PDCs and fuses from SDCs.

Lock/block switches if feasible. Secure removed switches and fuses under supervisors control.

Affix appropriate warning tags (AF Forms 979, 980 and 982) to switches and controls.

Check to assure all necessary switches have in fact been rendered inoperative.

Perform voltage tests to assure lines are actually de-energized (be sure to use the appropriate high voltage tester, not your everyday voltmeter).

Install temporary grounding on de-energized lines.

Perform repairs or maintenance as required.

Inspect work to ensure all is complete and proper, remove tools and materials from immediate worksite.

Notify all personnel that the system will be re-energized and to stand clear.

Remove temporary grounding.

Remove tags from switches and unlock controls/switches.

Verify all personnel are clear of worksite.

Reinsert switches/fuses and restore service.

First Aid

Personnel in the electrical and power production career fields receive considerable instruction in emergency actions and first aid, both as part of their peacetime skill proficiency training and as part of the contingency Prime BEEF training. Although emergency tasks such as pole-top rescue or manhole rescue are not usually encountered with the use of the Harvest Falcon electrical system, the critical hazard of electrical shock obviously still exists. Personnel installing, operating and maintaining the Harvest Falcon electrical generation and distribution system must be capable of responding to the effects of electrical shock on fellow workers quickly and properly. All personnel must continue to receive training in cardiopulmonary resuscitation (CPR), bleeding and wound control, shock management and burn treatment. Such training is even more important under deployed conditions. The new unfamiliar surroundings, unique Harvest Falcon equipment, extended work hours, and pressure to get the job done all increase the potential for serious accident and injury.

SITE SELECTION AND LAYOUT

Topography

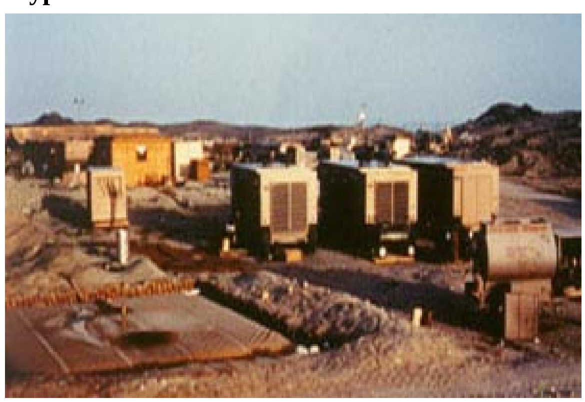
The general location of the primary power plant (figure 11) is determined by bare base facility planners (primarily engineer officers and engineering personnel) with input from electrical personnel. If dispersed plant operation is called for, all plant locations will be identified. With general locations decided, specific sites can then be picked out by on-the-ground physical inspection. In determining the specific sites consider the following:

Ensure the area is large enough area to accommodate all equipment assets (generators, fuel bladders, berms, PDC, expanded shelter container (ESC), etc.

Plan for security fencing (concertina wire or similar) around the perimeter

Look for relatively level land to minimize site preparation

Figure 11. Typical Bare Base Power Plant.



Plan for some site preparation to provide extremely level ground for fuel bladders and PDC

Plan on site preparation to provide berms for fuel bladders

Check area for reasonable drainage patterns

Make sure access to site is not inhibited by drainage ditches, swales or irregular terrain

Allow trees on site to provide shade and some camouflage but not block air flow

Leave low ground cover undisturbed as much as possible to minimize blowing dust and dirt

Noise Considerations

Part of the site selection process includes consideration of the noise generated by power plants. Bare base planners normally take this into account by placing power plants at locations as distant as possible from cantonment and administrative type areas. Besides distance, the use of tree lines and natural ground contours between power plants and highly populated areas can reduce noise interference. In barren regions manmade revetments and baffles have also been used as noise barriers. Lastly, to the extent practicable, plants should be situated in such a manner as to use the prevailing winds at an installation to reduce the noise factor. Locate power plants downwind of high use areas.

Vehicle Access

Of critical importance to primary power plant operation is vehicle access, particularly for larger trucks and heavy equipment (figure 12). Once a plant is established, large vehicles will still require access for delivery of operating supplies and repair parts and refueling vehicles will visit the plants virtually daily. Sufficient space should be allowed to enable removal of an entire generator unit for depot level repair without tearing up plant equipment or moving assets around. Also remember there may be a time when burial of electrical cables will be desired—it's much easier to bring in the trenching machine rather than hand-dig hundreds of feet of trench in desert hardpan or rock filled frozen earth. If an extended contingency operation appears probable, it is advisable to build hard surface vehicle accessways at least to the refueling points. If blacktop roads are not possible, go with soil cement or gravel. Also be sure to consider fire fighting access. Get with your base fire chief to determine realistic space requirements, different bases have different fire fighting vehicle sets. As a minimum, plan your plant layout so as to allow complete accessibility to its entire perimeter.

Figure 12. Movement of Power Plant Assets.

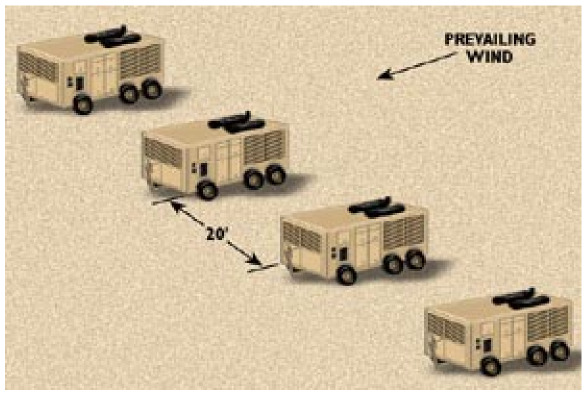
Equipment Layout

Although the same basic equipment is used in all bare base power plants, there are many possible equipment layout configurations. These configurations are influenced by two basic factors—the size of the bare base population (determines quantities of assets received) and whether dispersed or non-dispersed operations are required (dictates number of plants set up). Within these configurations, there is no mandatory way to layout individual equipment items. Individual equipment item layout will be driven by land area available, vehicle access needs, available lengths of cable and piping and, to some extent, operational requirements.

Generators. Harvest Falcon high voltage generators are the MEP-012A, 750 kW diesel driven units providing 3-phase, 4,160-volt, 60-cycle power (figure 13). The MEP-012A consumes 55 gallons of fuel per hour at full load and normal environmental conditions. It weights 25,000 pounds and completely loads a C-130 cargo aircraft. Each unit comes with switch gear controls and output power conductors (high voltage) and is fully enclosed with weatherproof access panels to all areas. They are towable by most bare base vehicles. The Harvest Falcon housekeeping set supporting the first 1,100 personnel on site contains four 750 kW generators. The Industrial Set contains one additional unit. For each 1,100-person increment added to the base population you can expect at least three additional generators. It is unlikely, however, that you will see more than one Industrial Set arrive at your installation. Layout of the generators at most bare base power plants tends to follow a similar pattern (figure 14). They are normally lined up parallel with each other and at least 20 feet apart. As is shown in figure 14, the generators are also positioned so that prevailing winds aid in cooling by blowing along the long axis of the generators. For long duration deployments in hot regions consider building sunshades over the generator sets to reduce solar heat buildup. Maintain at least a 2' clearance between the sunshade and the top-mounted muffler on the generator.

Figure 13. 750-kW Generator.

Figure 14. Typical Generator Layout.



Primary Distribution Centers (PDC). The PDC (figure 15) receives and distributes 4,160 volt, 3-phase 3-wire delta electrical power from up to four generators. Six outputs, three on each side of the PDC, distribute high voltage power to other components of the bare base electrical distribution system. The use of load break elbows with the PDC allows a feeder or generator to be easily disconnected when maintenance is needed. There are no measuring devices on the PDC to assist the operator in determining overload, phase balance, power factor or underload conditions for the individual feeders. Each PDC weights 6,660 pounds. These other components include other PDCs or secondary distribution centers (SDCs). Two PDCs are included in the Harvest Falcon Housekeeping Set. One PDC is included as part of the power production facility unit type code (UTC) XFBEX; a second PDC arrives as a separate entity under UTC XFBEF. To ease communication and coordination between power plant operators and minimize cable runs inside the plant, PDCs are normally positioned no more than 80 feet from the generators. Figure 16 illustrates the typical PDC location in relation to the primary generators. PDCs must be placed on level ground, no more than 1% gradient. Ten feet of clearance around the PDC and 6 feet of clearance above the PDC must be maintained. This provides working room and allows heat dissipation.

Figure 15. Primary Distribution Center.

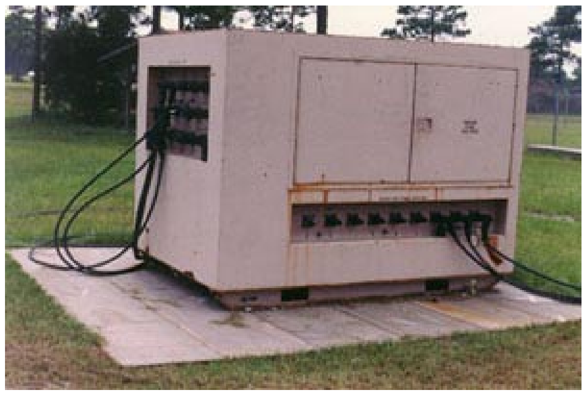
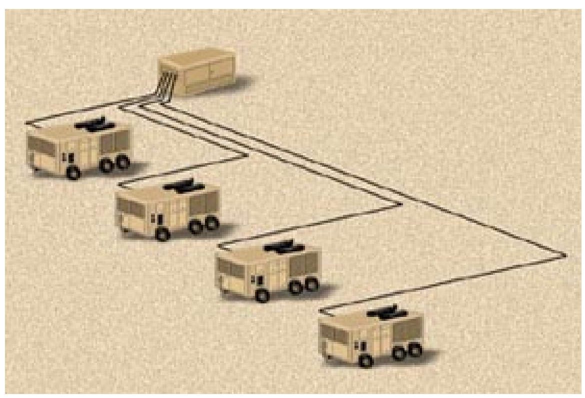


Figure 16. Typical PDC Location.



Fuel Bladders/Berms. The 750 kW generators are designed to operate on a wide variety of fuels. These include DF-2, JP-4, JP-8 DFA (Arctic Grade Diesel), and commercial jet A-1. A forty-two gallon fuel tank is located on the unit itself for start-up checks and maintenance purposes. However, the

750 kW generator consumes fuel at a rate of approximately 55 gallons per hour at full load. This equates to the consumption of about 440 gallons during an eight-hour period of operation. To ensure an adequate continuous fuel supply, connections are provided to accept fuel from external fuel sources, such as fuel trailers or fuel bladders. In the Harvest Falcon system, generator fuel storage is handled by 10,000-gallon fuel bladders (figure 17). The Housekeeping Set includes two bladders in the power production facility UTC XFBEX. An additional bladder is part of the Industrial Set under UTC XFBF1. Each bladder weights 230 pounds. When setting up a power plant, normally one bladder is provided for every two 750 kW generators. Figure 18 depicts the common placement of the fuel bladder with respect to the generators. The 10,000-gallon fuel bladders have a footprint of approximately 12 feet by 42 feet when empty and a height when filled of about 4 feet. The ground under the fuel bladders requires some preparation, however, before bladders can be positioned. An area 16 feet by 46 feet must be well leveled and any debris or sharp objects must be removed. Leveling is important to prevent the bladder from "creeping". To prevent a massive fuel spillage in case of a tank rupture, a 3 ½ foot high berm must be built around each bladder. The inside ground dimensions of the berm should be 16 feet by 46 feet to allow a two foot working area around the entire bladder. If sufficient material is available, a 4-inch thick sand bed should be provided under the bladder. A drain with valve should also be installed in the berm wall to allow draining of surface water. See figure 19 for berm details. Carefully consider where you place the fuel bladders. Don't put them in a location that would permit fuel from a ruptured bladder and berm to flow downhill into other base areas or waterways. Lastly, be sure you have developed a plan for fuel containment in case a bladder and berm rupture or refueling operations result in major spillage.

Figure 17. Fuel Bladder Supporting 750-kW Generator.

Figure 18. Fuel Bladder Placement.

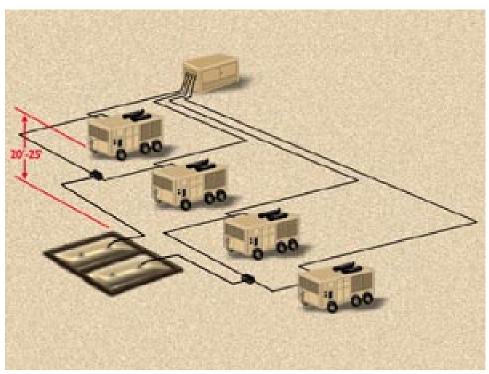
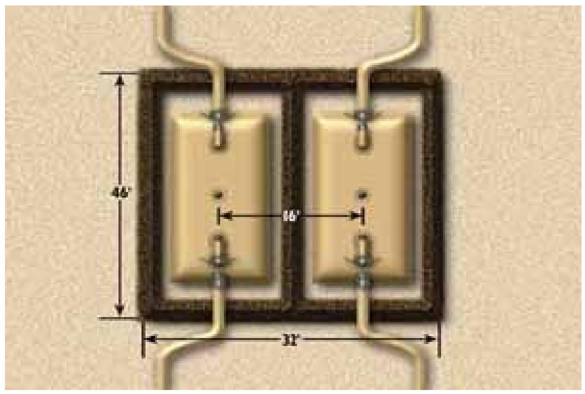


Figure 19. Typical Fuel Bladder Berm.



Expandable Shelter Container/Control Panels. Included in UTC XFBEX are two items needed to establish a control center for operating the power plant—an expandable shelter (ESC) (figure 20) and an equipment rack (figure 21). The ESC is used as control room structure. When fitted with a bare base air conditioner the ESC provides an climatically controlled, relatively noise free facility for plant operation. The equipment rack, weighing 450 pounds, is placed inside the ESC. Each 750 kW generator comes with an individual control panel (figure 22) which is removable and normally installed in the equipment rack. The equipment rack can accommodate control panels from up to four 750 kW generators. The control panels come with three interconnecting 50-foot cables, for a maximum 150-foot cable length (figure 23). This cable length will dictate where the ESC and equipment rack can be placed. While there is no one specific position the ESC must be placed in with relation to the generators, keep the control cable length limitation in mind when planning out your plant set up.

Figure 20. Expandable Shelter Container.

Figure 21. Equipment Rack.

Figure 22. 750-kW Generator Control Panel.

Figure 23. Control Panel Cable.

Remote Area Lighting Set (RALS). Another item included in UTC XFBEX is a remote area lighting set (figure 24). This set is one of several that will usually be deployed to a contingency location but this particular set is meant to be dedicated to power plant support. It is used at a power plant to provide overall general lighting for safety and security and specific lighting for more critical or technical operations such as refueling. The RALS includes a panel box/receptacle container, 13 light pole and fixture assemblies, cables to connect the lights to the panel box, and cables to connect the panel box to an SDC. The panel box/receptacle container also serves as the storage and shipping container for the cables and lights. Although the lights work using photocells, the panel box/receptacle container should be placed within the power plant compound (perimeter fence) for security purposes and in case manual operation is ever desired. The cable provided for connection to an SDC is only 250 feet long, therefore you'll have to ensure an SDC is nearby. The same SDC should also provide service to the power plant ESC and air conditioner. Twelve of the 13 lights are connected to four 375-foot cable sections. Normally two strings of six lights are set up, each string 750 feet long. Each string is plugged into the panel box/receptacle container. The thirteenth light fixture

Figure 24. Remote Area Lighting Set.

is mounted on the panel box itself. Remember, however, that the RALS does not have an internal power source; it relies on getting power from an SDC. For emergency purposes, it is wise to have one or two of the TF-1 floodlight sets provided in the Harvest Falcon package immediately available to support power plant operations.

CONNECTIONS

Grounding of Equipment

Proper grounding of the Harvest Falcon electrical system is crucial for the safety of our electrical and power production personnel. Procedures for grounding of this deployable system differ little from those used in standard electrical system installations. The grounding system for the Harvest Falcon electrical system basically consists of ground rods at major components and grounded neutral wire throughout the high voltage distribution portion of the system. See the applicable equipment technical orders for specific grounding methods.

Ground rods are normally driven vertically into the earth near equipment items to be grounded and connected to the chassis or frame of the component with #2 AWG or #4 AWG copper wire (figure 25). Drive the rod to a depth of at least eight feet. Soil characteristics play a large part in the suitability of the grounding network. Ideally, a soil resistivity of 25 ohms or less is required for satisfactory grounding results. The type of soil, its chemical contents, and the moisture level surrounding the ground rod will determine the resistance. For example, clay and loam soils with no rocks or stones will have a much lower resistance than clay or loam soils with many rocks or stones. Sand and stones alone will have a much higher resistance. Moisture content also affects resistance readings dramatically. As moisture content increases, soil resistivity decreases. This is especially true at the lower moisture content levels. For good grounding you basically want the ground rod to reach a depth where the surrounding soil is always moist. Not all locations, however, will have soil conditions favorable for ground rod installation. You may encounter areas where a ground rod cannot be driven deep enough. In such cases you may have to use a horizontal ground rod installation (figure 26) or a laced wire grounding installation (figure 27). Dig the trench as deep as feasible but be sure you go below the frost line if you're in a climatic zone where freezing is possible. If soil freezes around a ground rod, the resistivity readings will increase substantially and the suitability of the ground could be lost.

Because you aren't as deep in the earth, you may have to place more than one rod assembly in the trench to obtain decent resistance readings. If ground rods are in short supply, you can use copper wire as a substitute. The copper wire is laced up and down the bottom of the trench. When backfilling the trench, compact as much as possible to maximize soil contact with the wire or rods. To keep resistance readings low under extremely adverse soil conditions, you may have to continuously keep the grounding area damp using water or salt water solutions. Lastly, the Harvest Falcon electrical system does not include any ground testing equipment; bring a testing instrument with you.

Figure 25. Typical Vertical Ground Rod Installation.

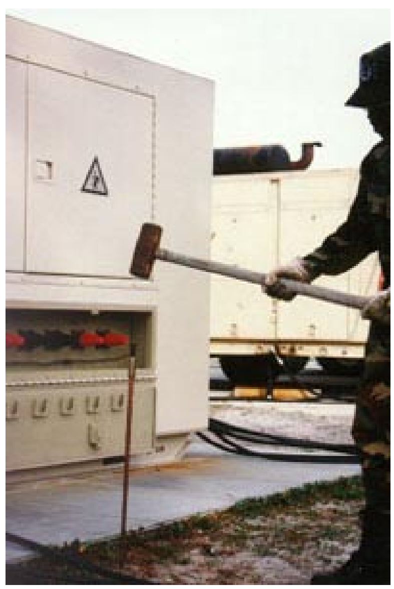


Figure 26. Horizontal Ground Rod Installation.

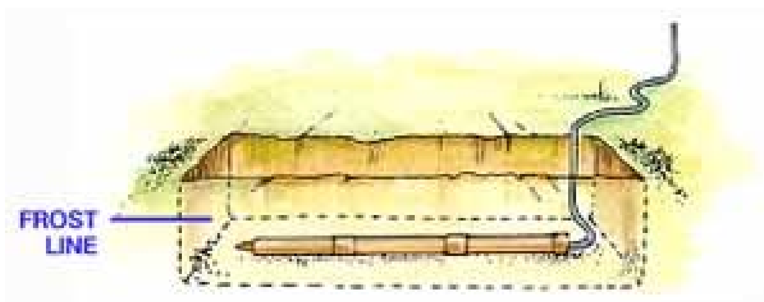
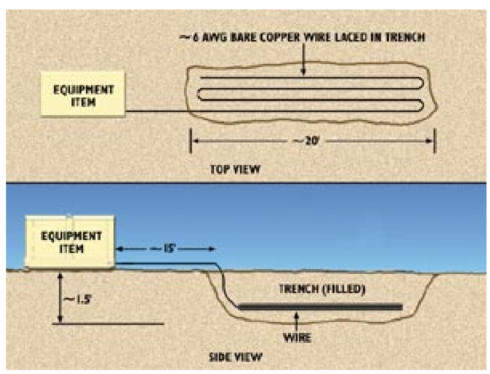


Figure 27. Laced Wire Grounding Installation.



Generator Grounding. Each 750 kW generator is attached to a ground rod usually placed near the ground stud (figure 28) at the front end of the generator. Connection is commonly made using a #4 AWG copper wire. Grounding of the neutral wire will be discussed in a later paragraph. Do not bond the ground rods of the generators together.

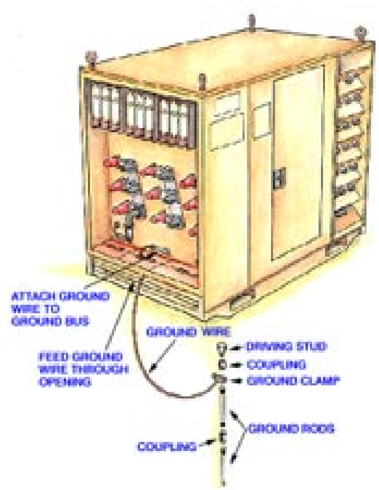
Figure 28. 750 kW Generator Ground Stud.

PDC Grounding. Ground rod installation is also required for PDC set up. Two ground rods are driven, one on each load side of the unit. They are connected to chassis grounding lugs located on the left front and right rear corners of the PDC using either #2 or #4 AWG copper wire. Drive the rods close to the grounding lugs to reduce tripping hazards (figure 29). Bond the two ground rods together with additional copper wire.

Figure 29. PDC Ground Rod Installation.

SDC Grounding. The grounding system for an SDC requires a single ground rod be placed on the high voltage side of the unit. After attaching the grounding cable (#2 or #4 AWG copper) to the rod, feed it through the opening at the bottom of the high voltage compartment and attach it to the ground bus located at the bottom of the primary mounting panel (figure 30).

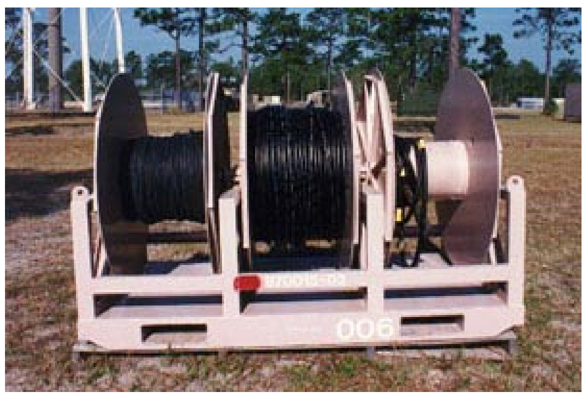
Figure 30. Grounding Connection For An SDC.



Connections From Generators To PDCs

Conductors from 750kW generators to PDCs are fabricated on-site since not all power plants will look identical or have the same “floor plan.” Included in the Harvest Falcon housekeeping set are six cable skids (figure 31) (two under UTC XFBEX and four under UTC XFBEG). Primary cable (#1/0 aluminum, 5-kV, cross linked polyethylene) is shipped on these skids, about 9000 feet per skid. You will have to cut this cable to length and install the load break elbows (figure 32) which fit the 750 kW generators, PDCs and SDCs. Follow the directions for installing the elbows carefully and be sure that 3-4 feet of the concentric ground wire extends below each one. You will need one cable for each of the three phases from a generator to a PDC. Be sure to use the standard color coding for each phase so connections are made properly. Color coding is as follows: phase A—black, phase B—red, and phase C—blue. You can use colored tape or spray paint to mark the cables (figure 33). If you are connecting more than one generator to a PDC, you must ensure all cables are connected correctly by phase otherwise a direct short will occur with accompanying equipment damage.

Figure 31. Cable Skids.



Start connecting the primary cables to the generator by first attaching each cable's concentric ground wire to the grounding point on the chassis of the generator (figure 34). Physical connection of the primary cables to the generator's bushing well inserts must be made using the Grip-All clamp stick. After removing the red dust caps from the bushings, position a load break elbow over one of the bushing well inserts and push it into place being sure that the elbow is completely seated (figure 35). This process will need to be repeated for all three phases. Before installing load break elbows, it is worthwhile to coat the connection points with silicone grease. This often makes it easier to install the elbows and helps prevent moisture and dirt from entering the connection. Repeat this process for each generator that is to be connected to the PDC.

Figure 32. Load Break Elbow.

Figure 33. Black, Red and Blue Markings Of Primary Cables.

Figure 34. Connection Of Concentric Ground Wires To Chassis Grounding Point.

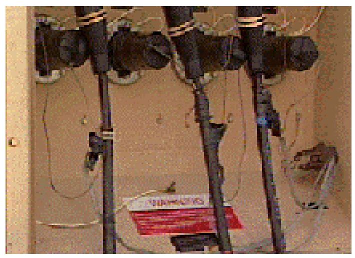


Figure 35. Placing Primary Cable On Generator.

After the primary cables have been connected to the generators, install the other end of the cables onto the line side of the PDC (figure 36). When doing so, it's important to make sure each phase being connected to the PDC is marked "A", "B", and "C" and all correspond exactly to the phase sources from the generators. If this is not done, it will be impossible to tie more than one generator to the PDC. Before physically connecting the cables to the PDC bushing well inserts, connect all the concentric ground wires from each cable to the grounding lugs across from each connection point (figure 37). Then connect the cables to the bushings using the Grip-All clamp stick. Install high voltage terminal caps on all the line side bushing well inserts that are not being used for generator connections. Any bushing well insert not being used on the line side is energized because they are connected to a common bus bar. When making high voltage cable connections, work with the equipment in the unenergized state.

Figure 36. Primary Cable PDC Line Side Connection.

Figure 37. Connection Of Concentric Ground Wires On Line Side Of PDC.

Connections From PDCs To SDCs.
High voltage connections from PDCs to SDCs are similar to those from the generators to the PDCs. Cabling is cut to length, load break elbows are installed on both ends of each cable, and cables are marked according to phase. Grip-All clamp sticks are used to make all connections. The PDC has six output feeders, three on each side of the unit. Each feeder has three phases marked “A”, “B”, and “C.” The concentric grounds from each cable are connected to grounding lugs below the bushing well inserts of the output feeders (figure 38). Then the load break elbows of each cable are connected to the bushing well inserts making sure phase coding is followed (figure 39). If any feeder circuits of the PDC are not going to be used, the arc strangler switches (figure 40) protecting these circuits should be removed thus totally isolating them from the power source. Additionally, red dust

caps should be placed on all of the unused bushing well inserts to protect them from dust, dirt, and adverse weather. Again, work with the equipment in an unenergized state.

Figure 38. Connection Of Concentric Grounds On Load Side Of PDC.

Figure 39. PDC Load Side Feeder Connections.

Figure 40. PDC with Arc Strangler Switches Removed From Unused Feeders.

Cables from high voltage sources are connected to the bushing well inserts on the high voltage side of the SDCs. A single SDC can accept a three-wire high voltage input either from a generator, PDC or another SDC. When facing the high voltage end of the SDC, the commonly used input connection bushings are on the left side of the panel face (figure 41). Normally the bushings are marked as input connections and have their proper phase identified on adjacent nameplates. Before connecting the cables to the SDC, remove the center pole of each of the three electric fusible disconnect switches by sliding it out of the switch using a hot stick (figure 42). This isolates the SDC transformers from the incoming power source. The concentric ground wires from each of the high voltage input cables must be connected to the ground bus plates at the bottom of the panel face (figure 43). Once the ground connections are made, the primary cables can be placed on the input bushing well connectors (be sure correct phase order is maintained). Any bushing well connectors on the SDC that are not going to be used should be covered with protective insulated caps. Once connections are made on the load side of the SDC and post-installation checks are completed, the electric fusible disconnect center poles can be reinstalled (see specific equipment and distribution system technical orders for details).

Figure 41. High Voltage Input Cables Connected to SDC Bushings.

Figure 42. Removal Of Electric Fusible Disconnect Switch Center Pole.

Figure 43. Concentric Ground Wire Connection At SDC.

Several SDCs can be connected to one feeder circuit coming from a generator or PDC. The other two sets of bushing well inserts on the line side panel face of an SDC are commonly used as output terminals. Cables can be connected from these bushings and run to input bushings of other SDCs (figure 44). Make sure proper phase order is maintained and concentric ground wires are connected at both ends of any SDC-to-SDC cabling.

Figure 44. Input and Output Cables On An SDC.

Connections From Generators To Control Panels

Generator control panels are an integral component of each generator unit. For long term operation or plant operation where several generators are in use simultaneously, control panels are removed from the units and installed in the control rack inside an ESC or similar facility (see figure 22). Six control cables, each 50 feet long (see figure 23), are used to connect the control panel to the generator. Because two cable runs are needed between the panel and the generator, the panel location is limited to 150 feet from the generator. Cable-to-cable connections are basic cannon plugs. One end of each of the cable lines is attached to the wiring harnesses that the control panel was originally connected to in the generator (figure 45); the other end of each cable is attached to the top of the control panel in the equipment rack.

Figure 45. Control Panel Cables Leaving Generator.

Fuel Bladder Connections

Harvest Falcon 750 kW generators are fueled using 10,000-gallon storage bladders. Normally, two generators are serviced from a single bladder. Bladders have three connections on their top surface (figure 46)—a filler assembly, a discharge assembly and a vent assembly. The vent assembly is simply a relief valve and standpipe and is attached to the fitting on the center of the bladder. The remaining two connections are fitted with elbows. One elbow is configured so that it is adaptable to fuel delivery vehicles, the other is connected to a manifold assembly (figure 47) using a 3-inch hose. Oftentimes a sandbag is placed under the 3-inch hose about two feet out from the elbow to reduce stress on the bladder fitting connection. Two 1-inch lines leave the manifold assembly and are attached to the generators (figure 48). Each generator has an internal pump to draw fuel; therefore, no external pumps are necessary in the fueling hose assemblies. You will probably receive only 50 feet of 1-inch hose for each generator which means your storage bladders must be set up relatively close to your generators.

Figure 46. Fuel Storage Bladder.

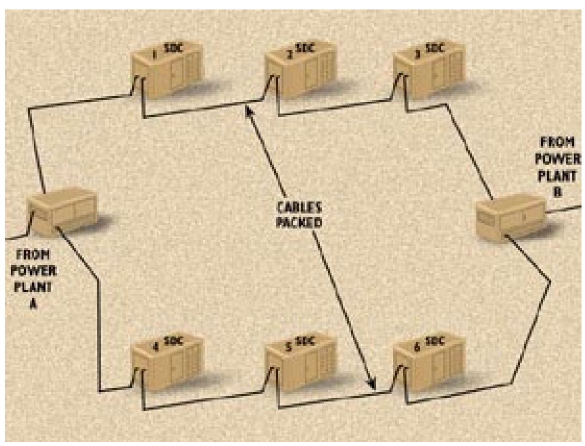
Figure 47. Fuel System Manifold.

Figure 48. Fuel Hose Connected To 750-kW Generator.

Connections Between Plants

At high threat beddown locations, facility dispersal is the norm. This also applies to power plants. Two or more plants should be established (quantity is predicated on population and size of the installation) to ensure some degree of electrical generation capability is retained after an attack or similar hostile act. These plants should be part of a loop electrical distribution network. Connections between plants can be accomplished by interconnecting the PDCs at each plant. The #1/0 aluminum, 5-KV primary cable and associated load break elbow connectors are used. This cable is of the optimum size for the load requirements and provides both adequate insulation and mechanical integrity when buried to the proper depth. The external neutral provides additional grounding capability and generally ensures that if personnel hit the cable with digging devices, a short circuit will occur at the point of contact, blowing a fuse at the PDC and hopefully avoiding injury to personnel. This cable weighs 4,603 pounds for three reels on a skid which equates to about ½ pound per linear foot of cable. Physical connection can be made from the output bushings of one PDC to the output bushings of another. Definitely be sure, however, that correct phasing is maintained and concentric grounds are properly connected. Plants can also be interconnected through SDCs on feeder circuits (figure 49). In figure 49, plant A feeds SDCs 1, 2, and 3 and plant B feeds SDCs 4, 5, and 6. The cables running from SDC 1 to SDC 4 are connected to a set of output bushings on SDC 1 and placed on parking stands next to a set of output bushings on SDC 4. If plant A is put out of service for some reason, it is isolated from the system and the cables at SDC 4 are removed from the parking stands and placed on the output bushings to energize SDCs 1, 2, and 3. Alternatively, the links between SDCs 1 and 4 and 3 and 6 can be made as the system is initially installed. In any case, again ensure correct phasing is maintained and concentric grounds are connected properly.

Figure 49. Power Plants Interconnected Through SDCs.



MAINTENANCE AND EMERGENCY PLANNING

This section addresses several points associated with the maintenance and emergency planning of power plant operations. However, it is not meant to detail the technical aspects of 750 kW generator operator or organizational maintenance…..these areas are more appropriately discussed in the equipment technical orders. Table 6 contains a listing of Harvest Falcon electrical systems technical orders.

Table 6. Harvest Falcon Electrical System Technical Orders.

Tech Order Number	Title
35C1-2-1-301	Electrical Distribution System, HF
35C2-3-459-1/-14	MEP-012 750kW Gas Turbine Generator
35C2-3-474-1/-4	MEP-012A 750kW Diesel Generator
35CA1-2-4-7	Primary Distribution Center
35CA1-2-6-1	Primary Distribution Center
35CA2-2-10-1	Secondary Distribution Center
35CA6-9-1	Equipment Rack
35E4-94-1	Expandable Shelter Container
37A12-15-1	Fuel Bladders

Generator Maintenance

As mentioned in an earlier section of this handbook, four 750 kW generators are included in the initial housekeeping set deployed into a bare base. Three of these units are sufficient for supporting the maximum demand electrical requirements of the housekeeping package. The fourth generator is meant to function as a rotational unit allowing periodic required maintenance to be performed on the other units. In low threat situations where generators are all located at a single power plant, the rotational generator is permanently connected to the primary grid system. In high threat locations with more than one power plant, the rotational generator is moved to the proper location when one generator is taken out of service. When more than one power plant is required, generators are interconnected in a loop system so that failure of a generator at one location does not interrupt service.

Maintaining data logs is often regarded as a nuisance factor in the day-to-day operational atmosphere. Nevertheless, these logs serve an important purpose. They assist you in keeping track of required maintenance needs, furnish trend information on operating characteristics, and often provide key data for analysis of power production problems.

PDC Maintenance

Since a PDC is basically a static device, maintenance is relatively minimal, a worthy attribute in a deployed situation. Several visual inspection tasks should be periodically performed however, and some preventive maintenance is required. See TO 35CA1-2-6-1 for details. Major items that require inspection and maintenance attention include:

Fused switch assemblies
Grounds and concentric conductors
Case and doors
Bushing well insert assemblies
Internal components—dielectric testing

Emergency Planning

Under routine conditions power plant operations can become very methodical and predictable. When emergency situations arise, however, one must be prepared for many situations and be able to respond rapidly and correctly. This capability must be preplanned and not based on instinct. An emergency operating plan is crucial for ensuring our people know what to do when a crisis occurs. This plan should include procedures to be followed under any of the following conditions:

Major trouble on the primary distribution system.

Partial outage of the electrical supply.

Prolonged outage of the electrical supply.

Major fuel/hazardous chemical spill.

The plan should also include or address the following:

A single line drawing of the total electrical distribution network. Major feeder circuits should be identified and each power plant, PDC and SDC location clearly marked. If cables have been buried, their locations should also be clearly delineated.

Facility priority list (used for determining MEP generator placement priorities in case of facility damage).

Refueling under emergency conditions. Procedures for refueling both low voltage MEP generators and 750 kW units should be spelled out to include responsibilities, timing, types and quantities of fuel, etc.)

Movement of low voltage MEP generators under emergency conditions. This includes vehicle requirements, tools, cabling requirements, etc.

Location and availability of spare parts and consumable items.

Contact points and procedures for ordering government-furnished supplies and equipment.

Local sources of resupply, fuel, and generating equipment.

Procedures for emergency load shedding identifying what circuits to isolate and in what priority.

WILLIAM P. HALLIN, Lt General, USAF
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